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Standard Method for Testing Full Scale Advancing Spill Removal Devices¹

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1. Scope

1.1 This standard provides a method for determining performance parameters of full-scale advancing oil spill removal devices in recovering floating oil when tested in a controlled test facility.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

- D 88 Test Method for Saybolt Viscosity²
- D 341 Viscosity-Temperature Charts for Liquid Petroleum Products³
- D 445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)³
- D 1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method³
- D 2161 Method for Conversion of Kinematic Viscosity to Saybolt Universal Viscosity or to Saybolt Furoil Viscosity⁴
- D 2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data⁵
- D 2905 Practice for Statements on Number of Specimens for Textiles⁵
- D 2906 Practice for Statements on Precision and Bias for Textiles⁵

3. Summary of Method

3.1 The spill removal device may be tested in a wave/tow tank or other suitable facility with a controllable test environment. Controlled test variables include device velocity relative to the water velocity, oil properties and slick thickness, wave conditions, and pertinent device variables. It is essential that the device be operated in a steady-state condition during the sampling period when oil encounter rate, recovery rate, recovery efficiency, and device parameters

are monitored, measured, and recorded.

4. Significance

4.1 This test method provides quantitative data in the form of oil recovery rates, throughput efficiencies, and oil recovery efficiencies under controlled test conditions. The data can be used for evaluating design characteristics of a particular advancing spill removal device or as a means of comparing two or more devices. Caution must be exercised whenever test data are used to predict performance in actual spill situations as the uncontrolled environmental conditions which affect performance in the field are rarely identical to conditions in the test tank. Other variables such as mechanical reliability, presence of debris, ease of repair, ease of deployment, required operator training, operator fatigue, seaworthiness, and transportability also affect performance in an actual spill but are not measured by this method. These variables should be considered along with the test data when making comparisons or evaluations of advancing spill removal devices.

5. Definitions

5.1 *oil recovery rate*—the volume of oil recovered by the device per unit of time.

5.2 *throughput efficiency*—the ratio, expressed as a percentage, of the volume of oil recovered to the volume of oil encountered.

5.3 *oil recovery efficiency*—the ratio, expressed as a percentage, of the volume of oil recovered to the volume of total fluids recovered.

5.4 *advancing oil spill removal device*—a device that removes spilled oil from the water surface when there is relative motion between the device and the water. The device may move through the surrounding fluid or it may be stationary and the surrounding fluid moved past the device.

5.5 *data collection period*—the period of time during a test run when the performance data is recorded.

5.6 *oil*—the fluid distributed on the water of the test facility and recovered by the spill removal device (see Section 8).

5.7 *oil encounter rate*—the volume of oil per unit time actively directed to the removal mechanism.

5.8 *oil slick thickness*—the average thickness of the oil slick encountered by the test device.

5.9 *full-scale equipment*—equipment of the size that is (or will be) available commercially.

6. Interferences

6.1 The table of results (see 13.1) shall address the possibility of test facility effects. For example, wall effects

¹ This method is under the jurisdiction of ASTM Committee F-20 on Spill Control Systems and is the direct responsibility of Subcommittee F20.12, on Removal.

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² *Annual Book of ASTM Standards*, Vol 04.04.

³ *Annual Book of ASTM Standards*, Vol 05.01.

⁴ *Annual Book of ASTM Standards*, Vol 05.02.

⁵ *Annual Book of ASTM Standards*, Vol 07.01.

may interfere hydrodynamically with the device's performance.

7. Test Facilities

7.1 At least two types of test facilities, a wave/tow tank and a current tank, may be used to conduct the test outlined in this method.

7.1.1 *Wave/Tow Tank*—A wave/tow tank has a movable bridge or other mechanism for towing the test device through water for the length of the facility. A wave generator may be installed on one end, or on the side of the facility, or both.

7.1.2 *Current Tank*—A current tank is a water-filled tank equipped with a pump or other propulsion system for moving the water through a test section where the test device is mounted. A wave generator may be installed on this type of test facility.

7.1.3 Other facilities, such as private ponds or flumes, may also be used, provided the test parameters can be suitably controlled and environmental regulations adhered to.

7.2 Ancillary systems for facilities include, but are not limited to, a distribution system for accurately delivering oils to the water surface, skimming systems to assist in cleaning the facility between tests, and adequate tankage for storing the test oils.

8. Test Oils

8.1 Three standard test oils for use with this test method are defined in Appendix X1. These oils cover a wide range of properties and are designated with respect to viscosity and specific gravity as light, medium, and heavy. These oils must be Newtonian fluids and may be crude, refined, or simulant.

8.2 If it is desired to use an oil with properties that do not correspond to a standard test oil, a statement must be made in the table of results (see 13.1) that a standard test oil was not used. This statement must discuss the effect of the nonstandard oil on test data with respect to the probable results using the most similar standard test oil.

8.3 The viscosity of oil varies greatly with temperature. Frequently test oils must be distributed in the test facility at temperatures different from the water temperature. When this occurs, the oil generally will approach the surface water temperature.

8.4 If oils that originally meet the conditions stated in Appendix X1 are reused, their properties may change and should be evaluated prior to reuse.

9. Safety Precautions

9.1 Test operations shall conform to established safety requirements for both test facility operations and oil handling. Particular caution must be exercised when handling flammable or toxic test oils.

10. Test Device

10.1 The test device shall be deployed in accordance with facility operating characteristics. The device must be operated in accordance with the manufacturer's specified operating instructions with respect to mechanical operations and established maintenance routines. Modifications to the device for testing purposes shall follow the manufacturer's recommendations and shall be recorded with the test results.

11. Calibration and Standardization

11.1 At the outset of the test, the independent or control test parameters are selected. Typical test variables include:

Test oils	light, medium, and heavy
Test speed	upper and lower limits and speed increments selected as appropriate
Oil slick thickness	appropriate increments for the device being tested
Wave conditions	wave characteristics of significant height, average length, and period and pattern may be varied as appropriate

12. Procedure

12.1 Prior to the test, select the operating parameters, such as tow speed, wave conditions, test oil, and oil distribution rate. Then prepare the facility and spill removal device for the test run. Occasionally, it may be necessary to preload the device with oil to achieve steady-state operation within a reasonable period of time. Any preload must be carefully measured and discharged into the device. Measure or note immediately prior to each test the following parameters describing ambient conditions:

- 12.1.1 Air temperature,
- 12.1.2 Water temperature near the surface,
- 12.1.3 Wind speed,
- 12.1.4 Wind direction relative to the test device, and
- 12.1.5 General weather conditions, for example, rain, overcast, sunny, etc.

12.2 Start the wave generator (if necessary), oil distribution system, tow mechanism or water flow, and the spill removal device to begin a test run. Direct the discharge flow of recovered fluid from the device into a holding tank or back into the test tank out of the device's sweep path during the transient start-up period. After steady-state operation is achieved, monitor the discharge flow to obtain performance data. The discharge may be pumped through a flow meter to obtain a flow rate and sampled periodically to obtain the oil-to-fluid ratio. Alternatively, the discharge may be diverted into calibrated sample tanks from which the flow rate and oil-to-fluid ratio may be determined. In either case, the data collection period begins when sampling starts and ends when sampling stops. During the data collection period or immediately thereafter, measure and record the following parameters:

- 12.2.1 Oil distribution rate,
- 12.2.2 Fluid recovery rate (oil and water),
- 12.2.3 Tow speed or current speed,
- 12.2.4 Wave characteristics,
- 12.2.5 Length of the data collection period,
- 12.2.6 Oil encounter rate, and
- 12.2.7 Operating parameters of the spill recovery device such as belt speed, weir setting, pump speed, etc.

12.3 At the completion of the data collection period, divert the discharge of the spill removal device back into the holding tank or test tank. Stop the wave generator, tow mechanism or water flow, oil distribution, and spill removal device. Analyze samples of the discharge to determine oil-to-fluid ratio. Analyze samples of the recovered test oil to determine the following:

- 12.3.1 Specific gravity,
- 12.3.2 Viscosity,
- 12.3.3 Surface tension,
- 12.3.4 Interfacial tension with respect to test tank water, and

12.3.5 Water content.

12.4 Perform the analyses in 12.3 at the surface water temperature or in such a way that the values of these parameters at the surface water temperature can be determined from the analytical data.

13. Calculation or Interpretation of Results

13.1 Prepare a table of results for the test run containing the following entries:

13.1.1 Test identification number.

13.1.2 Date and time of day.

13.1.3 Average speed (tow speed or current speed) during data collection period.

NOTE—This rate is averaged over the data collection period.

13.1.4 Test oil type (light, medium, heavy, or non-standard).

13.1.5 Oil slick thickness.

13.1.6 For regular waves, include height, average period (or length), and whether head or following. For irregular waves, include significant height, significant frequency, spectral characteristics, and whether head or following.

13.1.7 Oil properties at test temperatures, including specific gravity, viscosity, surface tension, interfacial tension with tank water, and initial water content of oil.

13.1.8 Total volume of oil distributed during data collection period.

13.1.9 Total volume of oil encountered during data collection period.

13.1.10 Total volume of fluid (oil/water) recovered during data collection period.

13.1.11 Average oil distribution rate (see Note).

13.1.12 Average oil encounter rate (see Note).

13.1.13 Average fluid (oil/water) recovery rate (see Note).

13.1.14 Average oil recovery efficiency (see Note).

13.1.15 Average oil recovery rate (see Note).

13.1.16 Average throughput efficiency (see Note).

13.1.17 Ambient conditions, including air temperature, surface water temperature, wind speed, wind direction, and brief statement of weather conditions during test run.

13.1.18 Length of data collection period.

13.1.19 Volume of oil in device at beginning of data collection period.

13.1.20 Volume of oil in device at end of data collection period.

13.1.21 Operating parameters of the device such as belt speed, weir setting, pump speed, etc.

13.1.22 Brief discussion of interferences or limiting factors (see 6.1).

13.2 If any of the data required by 13.1 are not applicable to the device being tested, a statement must be included in the table of results describing the reasons for omitting the data.

14. Precision and Accuracy

14.1 Statistical measures of accuracy and precision may be determined that will indicate the reliability of test results as well as the degree of standardization in test procedures. Examples of procedures may be found in Appendix X2.

APPENDIXES

X1. STANDARD TEST OILS

X1.1 General

X1.1.1 The ranges of physical properties for standard test oils will be as outlined in X1.2 through X1.5.

X1.2 Viscosity

X1.2.1 *Light Oil*—3 to 10 cSt (mm^2/s) at 60°F (15.6°C).

X1.2.2 *Medium Oil*—100 to 300 cSt (mm^2/s) at 60°F (15.6°C).

X1.2.3 *Heavy Oil*—500 to 2000 cSt (mm^2/s) at 60°F (15.6°C).

X1.3 Specific Gravity

X1.3.1 *Light Oil*—0.83 to 0.88.

X1.3.2 *Medium Oil*—0.90 to 0.94.

X1.3.3 *Heavy Oil*—0.94 to 0.97.

X1.4 Surface Tension

X1.4.1 *All Oils*—24 to 34 dynes/cm (mN/m) with distilled water at 77°F (25°C).

X1.5 Interfacial Tension

X1.6 *All Oils*—26 to 32 dynes/cm (mN/m) with distilled water at 77°F (25°C).

X2. DETERMINATION OF PRECISION AND ACCURACY

X2.1 The following properties may be determined by the ASTM standards listed which are considered for use in this method for full scale advancing skimmers:

X2.1.1 *Viscosity*—Methods D 88 and D 445.

X2.1.2 *Specific Gravity*—Method D 1298.

X2.1.3 *Viscosity versus Temperature*—Standard D 341.

X2.1.4 *Viscosity Conversion*—Method D 2161.

X2.1.5 *Interlaboratory Testing*—Practice D 2904.

X2.1.6 *Number of Test Replicates*—Practice D 2905.

X2.1.7 *Precision and Accuracy*—Practice D 2906.

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